TITLE: An Evaluation of the Feasibility of Combining Carbon Dioxide Flooding Technology with Microbially Enhanced Oil Recovery Technologies in order to Sequester Carbon Dioxide

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1. ABSTRACT

Program Introduction: Rationale and Objective

Tertiary oil recovery technologies such as microbially enhanced oil recovery and CO_2 flooding have the potential to be coupled together for synergistic effects. For example, microbially enhanced oil recovery technologies depend on the in situ activities of the microorganisms to enhance the mobility of the oil (e.g. surfactant production) or thru the modification of the oil formation permeability via selective plugging to enhance the sweep efficiency of the injection water. Another tertiary technology is the injection of CO_2 to solubulize the oil and extract it from the formation it is contained. A well known fact is that all microorganisms have the ability to convert CO_2 into cellular components. The question arises as to whether these two technologies could be combined to enhance oil recovery while converting the CO_2 into lipids, proteins, and/or sugars. Therefore the objective of this project is to determine if microorganisms previously isolated from a subsurface oil formation have the ability to convert radiolabeled CO_2 into cellular components or by-products.

Accomplishments Achieved During the Current Period of Performance

During the current period of performance, September 2007 – March 2008, several subsurface isolates were evaluated for their ability to convert exogenous sources of CO_2 into lipids or proteins and byproducts such as organic acids or methane. The results from this study indicate that twelve of the seventeen cultures tested were capable of converting radiolabeled $^{14}CO_2$ into lipids under the growth conditions specified. These cultures are given in Figure 1 and labeled as 43, 89, 80, 84, 21, 6, 72, 71, 67, 65, 42 and 88 produced fatty acid amounts 2X that found in the controls. Three of these 72, 71 and 88 converted 0.8-1.6% of the $^{14}CO_2$ into fatty acids. The other cultures did not show fatty acid production above the controls. In addition to the production of fatty acids these cultures also converted significant amounts of the available $^{14}CO_2$ into CH_4. The cultures showing the greatest production were 71, 72, and 88. Interesting these cultures converted 74%, 61%, and 66% of the $^{14}CO_2$ placed into the vials, respectively. Culture 67 also demonstrated a very high conversion of $^{14}CO_2$ into a compound

soluble in the media. In fact almost 50% of the $^{14}CO_2$ was converted into this material. The major difference between this experiment and the previous ones is the age of the cultures utilized here. These cultures received $^{14}CO_2$ during the exponential growth phase of their life cycle. The previous studies utilized early to late stationary phase cells. Another culture designated 72 also converted and excreted a media soluble product from the $^{14}CO_2$. The identity of these compounds is not known but is suspected to be fermentation by-products such as acetic acid, ethanol, etc since these experiments were carried out under anaerobic conditions. Cultures 67, 71, and 88 also showed $^{14}CO_2$ being incorporated into protein. The results of these experiments demonstrate the multitude of products that can be produced from CO_2 under anaerobic condition by microorganisms cultured from subsurface oil bearing formation. The CO_2 converted into products and secreted back into the environment build up during pure culture work but would most likely be metabolized in a natural environment by another microorganism. The resulting products then would be protein, lipids, CH_4, etc. The use of single cultures in these experiments allows a more detailed determination of the fate of CO_2 that would most assuredly be masked by competing microbial processes.

These results demonstrate the ability of some of these sub-surface isolates to ligase exogenous sources of CO_2 to metabolic intermediates such as acetyl-CoA to form malonyl-CoA. The evidence to support this belief comes from the presences of these radiolabeled compounds in all of the different fractions. The ability of some of these cultures to produce as much as 50% of the $^{14}CO_2$ could have tremendous potential as a renewable energy source. This could be enhanced by the conversion of other microbes $^{14}CO_2$.

Plans for the Remaining Period of Performance

The work planned for the remaining period on the contract is listed below:

- Determine the kinetic rate of CO_2 conversion for one of the active subsurface isolates.
- Perform an economic analysis of the process to determine if any benefit occurs from this synergism.
- Publish the outcome of these investigations.

2. LIST OF PUBLISHED JOURNAL ARTICLES, COMPLETED PRESENTATIONS AND STUDENTS RECEIVING SUPPORT FROM THE GRANT

Conference Presentations

- Combining Microbially Enhanced Oil Recovery with CO2 sequestration, T. French, R. Hernandez, L. Brown, L. Prewitt, and G, Zhang. Annual Meeting, American Institute for Chemical Engineering. 2007.

Students Supported Under this Grant

- None.